APPENDIX A

Alternative Fuels and Propulsion

Introduction

This appendix provides descriptions of alternative fuels and propulsion systems as well as advanced emissions control systems for conventionally fueled vehicles available for use at federally-managed land sites. Conventionally fueled vehicles are standard gasoline- and diesel-fueled vehicles. Alternative fuel and low-emission vehicles include electric drivetrain vehicles as well as natural gas, propane, biodiesel, and alcohol fuels as described in Table A-1, which is located at the end of the text.

These vehicle and fuel descriptions are intended to provide a quick reference and starting point for investigating the purchase and implementation of low-emission vehicles at federally-managed land sites. Purchasing of any alternative fuel vehicles should be a part of an overall transportation planning effort performed by the federally-managed land site, as described in the planning guidebook.

This appendix describes alternative fuels and low-emission technology vehicles in several subsections as follows:

- Why Consider Alternative Propulsion Systems – an overview of why alternative propulsion. systems and low-emission vehicles are important to consider for visitor and other transportation at federally-managed land sites.
- Selecting Alternative Fuels – information is provided regarding evaluation of various alternative fuels options.
- Alternative Fuel and Low-Emission Vehicle Propulsion Technologies – describes alternative fuel and low-emission technologies.
- Alternative Fuels Used At Federally-managed Land Sites – examples of other alternative fuel projects in parks and federally-managed lands.
- Sources of Alternative Fuel Vehicle Technology Information –publications, references, and Internet web addresses of useful sites containing information on alternative fuel vehicles.

Why Consider Alternative Propulsion Systems

Concern for the environment and air quality, more stringent exhaust emissions standards, and growing dependency on imported petroleum were principal drivers for use of alternative fuels and propulsion systems. Alternative fuels use, in most applications, is more expensive than conventional fuel use. The economics of alternative fuel use has been steadily improving with wider implementation, expanding beyond niche applications where the economics can be advantageous. The potential for lower exhaust emissions, desire for a "green image", and lower noise levels of vehicles with electric drive technologies, as compared to conventional vehicles, can offset the extra cost of vehicles, fuel, or infrastructure changes.

Several important laws have encouraged use of alternative fuels, in particular, the Clean Air Act Amendments (CAAA) of 1990, the Energy Policy Act (EPAct) of 1992, and the Alternative Motor Fuels Act (AMFA) of 1988 and various executive orders. These acts have been focused on the viability of alternative fuels as replacements for conventional fuel (diesel and gasoline), the reduction of imported petroleum usage for energy security concerns, and the reduction of /vehicle emissions. Clean or low-emissions technologies are often discussed in terms of the full life-cycle emissions of the fuel and vehicle technology. Life-cycle emissions include the fuel production, formulation/preparation, distribution, and

dispensing as well as the vehicle emissions from the tail pipe and on-board fuel system (evaporative emissions). Life-cycle emissions are important to remember when considering greenhouse gas emissions (includes carbon dioxide and methane).

Both the CAAA (Clean Fuel Fleet Programs) and EPAct require light-duty fleets in the federal and state government, municipal, fuel providers, and private fleets to make a portion of their new vehicle purchases alternative fuel powered. EPAct allows the purchase of heavy-duty alternative fuel vehicles to substitute for the purchase of several light-duty vehicles. There also are Presidential Orders and local incentive programs that promote the use of alternative fuels and low-emission vehicles in fleets. There are currently no Federal fleet mandates for the use of alternative fuels in heavy-duty fleets.

Driving factors for considering low-emission vehicle technologies at federally-managed land sites are the public expectations of cleaner air and an environmentally friendly experience. The National Park Service, the Bureau of Land Management, and the U.S. Fish and Wildlife Service, with their environmental stewardship role and the clean technology mandate of the Department of Interior, are expected to be leaders in this area.

Selecting Alternative Fuels

Selecting alternative fuels and low-emission technology vehicles for use at a particular federally-managed land site involves consideration of many factors. Each site has unique transportation needs and operating environment. Questions to consider at the start of planning for alternative fuel vehicles are:

1. What are the transportation needs (daily ridership, heating or air conditioning of buses, etc.) within the federally-managed land site?
2. Which vehicles is the federal land site considering adding or replacing in the next year or two (this should include more than just visitor transportation); what vehicles will be added or replaced in the next five years?
3. What vehicles are available in the class range (light duty, heavy duty) and application needed?
4. What is the budget for vehicles and infrastructure at the federally-managed land site?
5. Which alternative fuels and technologies are readily available near the federal land site? Are there existing refueling stations available nearby with alternative fuels available? Will a "fuel supplier" provide an alternative fuel station that is convenient and economical for on-site vehicle use?
6. Are the technologies being considered suitable for the intended operating environment?
7. Are the fleet managers, including drivers, supervisors and maintenance staff dedicated to implementing the technology?

Each fuel and technology has its advantages and disadvantages that will need to be considered. One fuel may not satisfy all needs and, in some cases, it may be necessary to consider using different fuels for different classes of vehicles (light-duty, heavy-duty). Furthermore, alternate fuels and advanced propulsion technologies have some additional safety issues that must be considered in planning for vehicle purchases, infrastructure modification, and construction. Table A-2, at the end of the text, shows some advantages and disadvantages of each technology being considered in this section.

Vehicle requirements should be defined for each potential alternative fuel and low-emission technology application. This includes consideration of purchase and operating costs of vehicles/technologies and refueling.

Issues to be considered in the selection of vehicles and technologies include the following:

- Vehicle purchase from original equipment manufacturer (OEM) or re-powering an existing vehicle and adding appropriate on-board fuel storage.
- Expected duty cycle of the vehicles to be added or replaced; this would include range requirements, average speed, and type of terrain.
- Initial and operating cost of conventional and alternative fuel vehicles for comparisons
- Infrastructure requirements for refueling, storage of vehicles, and maintenance of vehicles; safety is a key factor here.
- Investigation of incentives to offset the cost of the vehicles, infrastructure, and upgrade of facilities; these incentives could come from federally-managed land sites, Department of the Interior, other federal funding, state and local government groups, or from alternative fuel suppliers.
- Availability of warranty service and support of the new vehicles and technologies. Many of the federally-managed land sites are in remote areas and may have a difficult time getting the support that they need.
- There may be other special issues to investigate, such as the ability of the roads to withstand the increased weight of some alternative fuel vehicles, coordination with the local communities and coordination with other federally-managed land sites to standardize purchases to reduce vehicle costs.

At each step of the selection process, it is important to access accurate, reliable information on each technology under consideration and to consult with experienced users and experts. An expert consultant with experience in designing and implementing alternative fuel fleets may provide useful insights and help. Champions for the project at the federally-managed land site will also contribute to a successful implementation. These champions should have the ability to allocate resources for problem solving and have interest in learning about the new technologies in order to become an in-house expert.

Alternative Fuel and Low-Emission Vehicle Propulsion Technologies

Conventional Fuel Modifications

Traditional highway fuels, both gasoline and diesel, are undergoing modifications to make them more acceptable for modern, cleaner burning engines. Several fuel modifications have been phased-in during the past five years and in many cases, allow engine manufacturers to produce engines that have significantly lower emissions levels.

Clean Diesel

Reduction of sulfur in diesel fuel has allowed the diesel engine to operate with lower particulate emissions (PM). Highway diesel fuel is now available with 0.05% sulfur content and allows heavy-duty (HD) truck engines to achieve a PM emission level of 0.10 g/bhp-hr (0.05 for buses). Even lower sulfur content (30 parts per million or lower) in diesel fuel is being discussed and should allow additional improvements.

New diesel engine fuels are also being developed that allow even cleaner diesel engine operation. The current potential fuels include: Reformulated diesel (much like reformulated gasoline), Di-methyl ether, Fischer-Tropsch diesel, diesel/water emulsions, and naphtha/water emulsions. Both major petroleum suppliers and heavy-duty engine manufacturers are experimenting with these new fuels to determine air quality benefits.

Reformulated Gasoline (RFG):

Various states and regions faced with air quality problem use reformulated gasoline. RFG programs have the ability to locally reduce the carbon monoxide and formaldehyde levels in the air. The RFG is a specially refined gasoline with lower vapor pressure, lower aromatics, and frequently contains a fuel "additive" that increases the amount of oxygen in the fuel. Popular additives used recently have been MTBE (methyl tertiary-butyl ether), ETBE, TAME, ethanol, methanol, and tertiary-butyl alcohol.

Use of MTBE is in the process of being phased out because of releases of MTBE into the country's water supplies. The levels of MTBE in potable water are increasing above suggested levels. Remediation of abandoned underground storage tank (UST) sites, phase-out of two-cycle marine engines, and other steps have been undertaken to resolve this potential health problem.

Vehicle & Engine Availability of Various Alternative Fuels

Natural Gas

Natural gas is being used successfully in a variety of heavy-duty and light-duty vehicles. The fuel is available both in gaseous and liquid forms. In gaseous form, it is called compressed natural gas (CNG) and is carried in high-pressure tanks (3,600 psi). As a liquid, it is call liquefied natural gas (LNG) and is carried in insulated, low-pressure cryogenic tanks (60-150 psi, -260 to -150F). LNG is more energy dense than CNG and, therefore, requires less fuel tank volume and weight than CNG. Both CNG and LNG entail some energy efficiency penalty. Typically, LNG is preferred for heavy-duty vehicles while CNG is preferred in lighter duty vehicles. However, CNG is commonly used in full size transit buses because they can accommodate the large and heavy CNG fuel tanks. LNG is used almost exclusively in heavy-duty trucks, but is also used in a few full-size transit buses.

A natural gas engine can normally operate with either a CNG or LNG fuel system. The heavy-duty engine manufacturers are well up the "learning-curve" for this alternative fuel and offer a wide variety of products with ratings from less than 200 to more than 400 horsepower. Light-duty CNG passenger cars, vans, and pickup trucks are offered by all major auto manufacturers. Several of these light-duty vehicles are offered in a "bifuel" configuration - this allows the vehicle to be operated on either CNG or gasoline. However, these bifuel configurations are typically less efficient and have higher emissions than dedicated natural gas vehicles. Use of both CNG and LNG also requires fueling infrastructure to store and dispense the fuel, and facility modification to ensure safe operation.

Alcohol Fuels

Both methanol and ethanol have been used in the heavy-duty and light-duty transportation markets. In heavy-duty applications, it was determined that both alcohol fuels could be used in "neat" (100% pure) form and would operate in high efficiency diesel engines. Although initially interest was high, these heavy-duty engines suffered significant reliability and durability problems and the fleet operators were disappointed in the engine's resulting life-cycle costs. No heavy-duty engine manufacturer currently offers product that can utilize either alcohol fuel.

In light-duty applications, both ethanol and methanol were blended with 15% gasoline and used in spark ignition engines. These vehicles are referred to as "flex fuel" vehicles and can operate on any available mixture of all gasoline and all alcohol blends (up to 85% by volume). "Flex fuel" suppliers include both Ford Motor Company, which offers a passenger car, and Daimler/Chrysler, which offers a van, that operates on E85 (85% ethanol + 15% gasoline). M85, a mixture of 85% methanol and 15% gasoline, is still available from a number of filling stations in California although no automobile manufacturer yet produces a compatible vehicle.

Propane (HD-5)

Propane is currently the most widely used alternative fuel in this country. Medium- and heavy-duty trucks are available from both Ford and Freightliner that can operate on propane. Ford also allows conversion (with full factory warranty) of certain gasoline powered vehicles to propane fuel if the conversion work is performed by a Ford authorized QVM (Qualified Vehicle Modifier). No propane-powered engine for use in full-size transit buses is currently offered.

Heavy-duty engine suppliers, Cummins and DDC (Detroit Diesel Corp), have been developing some products that can operate on propane. Cummins currently offers their B5.9LPG engine that is EPA certified with propane fuel.

Biodiesel (B20 & B100)

B20 (20% biodiesel and 80% petroleum diesel) does not require engine modifications or purchase of special vehicles to utilize the fuel. However, only modest improvements in exhaust emissions have been reported with minor changes in engine timing. B20 biodiesel fuel is compatible in any diesel engine. On-going demonstrations in some states are currently validating acceptance of B20 fuel in limited heavy-duty applications.

Neat biodiesel (B100, i.e. 100% biodiesel) may also be used in diesel powered vehicles without modifications and is considered an alternative fuel by EPAct (Energy Policy Act). Because of cold weather filter plugging problems and high fuel cost (~ $4.00 per gallon), no current demonstrations of this fuel are known. However, B100 fuel could be used in southern-tier states, where the temperatures typically do not fall below 40 degrees F, the temperature at which vehicle fuel filter plugging has been observed.

Electric Drivetrain Technology

Batteries - Battery-powered vehicles are used successfully in both light and heavy-duty vehicles, mostly in niche applications. Two major automotive manufacturers offer battery powered light-duty trucks. Both GM and Ford have light-duty pickup trucks available powered by lead-acid batteries that offer operating ranges of 40 to 60 miles between recharging. Several medium-duty buses are also being manufactured that use various battery technologies.

Major improvements in the quantity of energy stored in batteries are being addressed by a joint industry/government program that is entitled the USABC (United Stated Advanced Battery Consortium). This consortium has funded research and development activities related to advanced vehicular batteries. Progress to date in achieving program goals has been disappointing, but several unique/improved batteries have been developed.

Fuel Cells - Because current storage batteries have limited energy storage capacity, manufacturers have embarked on several paths that explore alternative methods of providing electric power to an electric motor - which drives the vehicle. Several companies and consortiums are developing fuel cells that can transform gaseous hydrogen directly into electricity. The hydrogen for the fuel cell can be carried as a compressed gas (but provides limited range) or as a hydrocarbon fuel (i.e.: gasoline, methanol, propane or natural gas). A small, on-board chemical plant (reformer) is used to strip the hydrogen from the hydrocarbon fuel, resulting in gaseous hydrogen for the fuel cell and improved fuel storage (range) for the vehicle. Programs are in very early stages of development and commercially available vehicles are not anticipated in the next five years.

Hybrid Electric - This technology combines a heat engine (small diesel, gasoline, natural gas, or propane engine) with an electric generator, and an electric drive motor. The internal combustion engine drives the electric generator, which powers the electric motor that propels the vehicle. The technology also traditionally uses intermediate storage devices (such as batteries or capacitors) to allow energy recovery from vehicle braking. Hybrid electric configuration allows greatly increased efficiency and lower emissions without costly infrastructure modifications. Several demonstration programs are currently underway for heavy-duty vehicles including buses with emissions levels comparable to CNG buses. Light duty vehicles are emerging in commercial availability.

Alternative Fuels Used At Federally-managed Land Sites

Examples of some alternative fuels/propulsion transportation currently in use at federally-managed land sites include the following:

Scotts Bluff National Monument - Biodiesel (B20) used in a 15 passenger van to transport visitors around the monument.

Mammoth Caves National Park - Developing infrastructure and facilities for ethanol (E85) use in park vehicles.

Yellowstone National Park - A 1995 Dodge Pickup "Truck-in-the-Park" program with a Cummins 5.9 liter diesel vehicle was operated for about a year and obtained 26,000 miles using B100 (neat) biodiesel fuel. Opacity of the exhaust was reduced by 50%. An identical Dodge vehicle and engine was tested using biodiesel for 4 years (100,000 miles) by the University of Missouri-Columbia and was analyzed by Cummins after the test. It showed that internal parts were exceptionally clean with minimal wear.

Grand Canyon National Park – natural gas and electric transit vehicles.

Zion National Park, Acadia National Park, and Lyndon Johnson National Historic Park –propane vehicles.

Cape Cod National Seashore – electric trams used for visitor transportation.

Table A-1: Alternative Fuels and Low-Emission Vehicle Technologies

Alternative Fuel or Technology	Description
Natural Gas	Natural gas is found in abundant supplies in the United States. It is a gaseous mixture, composed primarily of methane (usually 90 percent or more) and other hydrocarbon gases such as ethane, propane, butane, and pentane.
• Compressed Natural Gas (CNG)	CNG is usually stored on-board at high pressure (either 3,000 psi or 3,600 psi maximum service pressure) for storage and then dispensed for vehicle usage. The fuel is stored in several high-pressure cylinders on the vehicle. Cylinders vary in weight, size and composition and can be made of steel or aluminum, or may have a steel, aluminum or plastic liner reinforced with carbon or glass fiber composite.
• Liquefied Natural Gas (LNG)	LNG is a cryogenic liquid stored in a vacuum-insulated tank that is usually a double-walled stainless steel construction. LNG is stored on-board a vehicle at 70 psi to 150 psi. This liquid fuel is vaporized (heated) into a gaseous state before entering the engine's fuel management system.
Propane (LPG, HD-5)	This fuel is also called liquefied petroleum gas (LPG), which consists primarily of propane and may have a significant amount of butane. HD-5 is the current propane fuel specification for on-road vehicles, referring to a fuel that has less than 5% propylene or butane content. The fuel is stored on-board the vehicle in single wall, uninsulated, 250 psi rated fuel tanks.
Biodiesel (neat, B20)	Biodiesel can be produced from any plant- or animal-derived oil product. This fuel can be used in the 100 percent biodiesel form (or neat) or be blended with diesel fuel (usually 20 percent biodiesel and 80 percent diesel, which makes up B20). Biodiesel and biodiesel blends can be stored in standard diesel tanks.
Alcohol	Alcohol is usually produced from agricultural products and waste products. Alcohol can also be made from natural gas and coal.
• Methanol (neat, M85)	Methanol is an alcohol produced primarily from natural gas. Because it also can be derived from biomass or coal, the domestic resource base for methanol is vast. Methanol fuel for vehicles can be 100 percent (or neat) or 85 percent methanol and 15 percent gasoline. Standard gasoline and diesel tanks can be used. Diesel engines can be modified to use M100 while M85 is typically used in light-duty, spark ignition engines.
• Ethanol (E95, E85)	Ethanol is an alcohol derived from biomass (corn, sugar cane, grasses, trees, and agricultural waste). Ethanol blends are usually composed of 95 percent ethanol and 5 percent gasoline, methanol, or a combination (E95). The five-percent gasoline and/or methanol are used to de-nature the ethanol, that is, to make it unsuitable for human consumption. Standard gasoline and diesel tanks can be used. Diesel engines can be modified to use E100 while E85 is typically used in spark ignition engines.

Table A-1: Alternative Fuels and Low-Emission Vehicle Technologies (continued)

Electric Drivetrain	Many new and future vehicle designs are incorporating electric drivetrain components such as electric drive motors and the ability to recover energy through regenerative braking (recover mechanical energy by converting it to electricity through the braking process). Electric drivetrain vehicles allow the usage of lower emissions technologies such as batteries and fuel cells.
• Battery Only	A battery only vehicle has an electric motor drivetrain with only batteries to provide power to the wheels of the vehicle.
• Hybrid	A hybrid-electric vehicle incorporates an electric motor drivetrain, batteries (or possibly capacitors or a flywheel) as an electric energy storage device, and an external power source (prime mover), such as an internal combustion engine or fuel cell.
• Fuel Cell	A fuel cell powered vehicle has an electric motor drivetrain and a fuel cell, which converts hydrogen and air to electricity to provide power to the wheels. The fuel cell powered vehicle may also include batteries for energy storage. The fuel cell needs an on-board source of hydrogen either stored as hydrogen or from a reformer using another fuel such as natural gas, methanol, propane or gasoline. These vehicles are in the developmental and early demonstration stage.
Low Sulfur Diesel and Gasoline with Advanced Catalysts and Filters	Gasoline and diesel fuels have a significant amount of sulfur in them. The sulfur in the fuel reduces the ability of a catalyst to reduce emissions products into more environmentally friendly components and contributes to the particulate emissions (PM) of the engine. With the sulfur content of diesel and gasoline fuels reduced significantly, more active catalysts in conjunction with a particulate filter can be used to significantly reduce emissions (some have suggested as low as current natural gas engine emissions levels).
Other Fuels	There are several other fuels under development with the potential to reduce emissions and the use of imported petroleum. These other fuels include p-series fuels (combination of renewable and fossil fuel), di-methyl ether (DME), diesel fuel produced from methane/natural gas through the Fischer-Tropsch process, water-emulsion fuels, and others.

Table A-2: Alternative Fuels – Advantages & Disadvantages Compared to Conventional Fuels

Alternative Fuel or Technology	Advantage	Disadvantage
CNG	Fuel can be less costly than traditional diesel or gasoline. Many vehicle types are available from OEMs and converters. Emissions are low, in some cases, much lower than diesel fuel vehicles.	Fuel storage causes significant increase in vehicle weight. Vehicle incremental cost is 15 to 20% and higher than diesel. Fueling infrastructure is costly. Operating range issue.
LNG	Lower vehicle fuel storage volume and weight than CNG for the same amount of fuel. Same fuel cost as traditional fuels. Emissions are low, in some cases, much lower than diesel fuel vehicles.	Vehicle incremental cost is 15 to 20% and higher than diesel. Fueling infrastructure costly and must be trucked from a limited number of sources. Operating range issue.
Propane	Available as highway fuel in most regions. Customer's recognition of fuel properties. Easily stored and relatively inexpensive (when compared to other alternative fuels). Emissions are low, but not as low as natural gas vehicles.	Slightly higher vehicle costs than conventional vehicles. Fueling infrastructure required. Not available for all vehicles.
Biodiesel	No modifications needed to diesel vehicles or fueling station. This is a renewable fuel with low life-cycle emissions. However, most heavy-duty applications use B20, or only 20 percent biodiesel with diesel. Some emissions benefits, especially in particulate matter.	Fuel more expensive than traditional diesel. B20 not considered an alternative fuel, but credits available for use. In cold climates, fuel clouds at a higher temperature than diesel fuel. Minimal, or no emissions improvement, particularly NO_x.
Methanol (M85 or M100)	Alternative fuel that satisfies EPAct. Some emissions benefits.	Expensive fuel not available in many states. Fuel may degrade some plastic and rubber components. Not available for heavy-duty engines.
Ethanol (E85 or E100)	Alternative fuel that satisfies EPAct. This fuel is considered completely renewable. Has low life-cycle emissions.	Expensive fuel not available in many states. Fuel may degrade some plastic and rubber components.
Battery	Zero emission vehicle. Quiet operation. Range issue can be minimized with use of fast or opportunity charging.	Range limited. Charging infrastructure required.
Hybrid Electric	Greatly improved efficiency. Lower, but not zero engine emissions. If diesel or gasoline hybrid, no costly fueling infrastructure required.	Limited operational experience. Expensive initial vehicle cost. Battery life unknown.
Fuel Cell	Replaces conventional engines. Very low emissions. Uses hydrogen, or other fuels reformed on-board to get hydrogen.	Not currently available except in demonstration vehicles. Very costly technology. Reformer needed to make hydrogen from hydrocarbon fuels or an infrastructure to provide hydrogen fueling.

Sources of Alternative Fuel Vehicle Technology Information

References for more detailed information on alternative fuels and propulsion for vehicles and infrastructure:

1. The National Park Service Transportation Planning Guidebook, National Park Service, September 1999, http://www.nps.gov/transportation/alt/guidebook/index.htm

2. Use of Alternative Fuels in Transit Buses, GAO, Washington, DC 20548, December 1999, GAO/RCED-00-18

3. Guidebook for Evaluating, Selecting, and Implementing Fuel Choices for Transit Bus Operations, Transportation Research Board, National Research Council, 2101 Constitution Avenue, N.W., Washington, DC 20418, 1998, TCRP Report 38

4. Alternative Fuel Transit Buses, Final Results from the National Renewable Energy Laboratory (NREL) Vehicle Evaluation Program, NREL, 1617 Cole Boulevard, Golden, CO 80401, October 1996, NREL/TP-425-20513

5. Design Guidelines for Bus Transit Systems Using Alcohol Fuel (Methanol and Ethanol) as an Alternative Fuel, U.S. Department of Transportation, Federal Transit Administration, Office of Technology, 400 Seventh Street, S.W., Washington DC 20590, August 1996, DOT-FTA-MA-26-7021-96-3

6. Design Guidelines for Bus Transit Systems Using Compressed Natural Gas as an Alternative Fuel, U.S. Department of Transportation, Federal Transit Administration, Office of Technology, 400 Seventh Street, S.W., Washington DC 20590, June 1996, DOT-FTA-MA-26-7021-96-1

7. Design Guidelines for Bus Transit Systems Using Liquefied Natural Gas (LNG) as an Alternative Fuel, U.S. Department of Transportation, Federal Transit Administration, Office of Technology, 400 Seventh Street, S.W., Washington DC 20590, March 1997, DOT-FTA-MA-26-7021-97-1

8. Design Guidelines for Bus Transit Systems Using Liquefied Petroleum Gas (LPG) as an Alternative Fuel, U.S. Department of Transportation, Federal Transit Administration, Office of Technology, 400 Seventh Street, S.W., Washington DC 20590, September 1996, DOT-FTA-MA-26-7021-96-4

9. Liquefied Natural Gas Safety in Transit Operations, U.S. Department of Transportation, Federal Transit Administration, Office of Technology, 400 Seventh Street, S.W., Washington DC 20590, March 1996, DOT-FTA-MA-20-7007-95-3

10. Summary Assessment of the Safety, Health, Environmental and System Risks of Alternative Fuel, U.S. Department of Transportation, Federal Transit Administration, Office of Technology, 400 Seventh Street, S.W., Washington DC 20590, and U.S. Department of Energy, Forrestal, 1000 Independence Ave., Washington DC 20585, August 1995, DOT-FTA-MA-90-7007-95-1

11. Compressed Natural Gas Safety in Transit Operations, U.S. Department of Transportation, Federal Transit Administration, Office of Technology, 400 Seventh Street, S.W., Washington DC 20590

12. Ground Transportation for the 21st Century. National Conference of State Legislatures and American Society of Mechanical Engineers. August 1999. NCSL 1560 Broadway, Denver, CO 80202

13. Alternative Fuels Guidebook: Properties, Storage, Dispensing and Vehicle Facility Modifications. Richard L. Bechtold, P.E. 1997. Society of Automotive Engineers, Inc. 400 Commonwealth Dr. Warrendale, PA 15096.

Fuel Advocacy Groups

1. Propane Vehicle Resource Guide, RR Publishing, Inc., 1580 Logan St., Suite 755, Denver, CO 80203, (303) 863-0521, http://www.rppublishing.com

2. NGV Resource Guide, RP Publishing, Inc., 1580 Logan St., Suite 755, Denver, CO, 80203, (303) 863-0521, http://www.rppublishing.com

3. EVs for Work and Play, Electric Vehicle Association of the Americas, 701 Pennsylvania Avenue, N.W., Fourth Floor, Washington, D.C. 20004, (202) 508-5995, http://www.evaa.org

4. Biodiesel Report, "The news source for the Biodiesel Industry", P.O. Box 104898, Jefferson City, MO 65110-4898

Internet Web Sites

Several web sites useful for the investigation of alternative fuel vehicles are given below:

General

Transit Cooperative Research Program
Transportation Research Board
http://www.nas.edu/trb/index.html
U.S. General Services Administration
http://www.gsa.gov
This site contains information on the alternative fuel fleets purchased by the U.S. Government.

DOE/Alternative Fuel Data Center
http://www.afdc.doe.gov/altfuels.html
General description and fuel supply information on the major types of alternative fuels can be found on this site. There is also information addressing training and safety issues when operating alternative fuel vehicles.

EPA Office of Mobile Sources
http://www.epa.gov/omswww
This site has information about emissions, regulations, and market incentives for alternative fuel vehicles.

Railroad Commission of Texas
http://www.rrc.state.tx.us/divisions/afred/afrd.html
This site provides information on the Alternative Fuels Research and Education Division (AFRED) of the Texas Railroad Commission.

West Virginia University Department of Mechanical and Aerospace Engineering
http://www.cemr.wvu.edu/~wwwatf/index.html
An overview of alternative fuel research activities at West Virginia University is found at this site.

California Energy Commission
http://www.energy.ca.gov/afvs/ABCsintro.html
This site contains a link to a guide to alternative fuel vehicles.

U.S. Department of Energy, Office of Transportation Technologies
http://www.ott.doe.gov/programs.shtml
This site contains a list of links to current U.S. Office of Transportation Technologies alternative fuel programs.

Energy Information Administration
http://www.eia.doe.gov
This site provide statistics on alternative fuel vehicle usage and alternative fuel usage.

American Public Transportation Association
http://www.apta.com
This site provides information on the transit industry.

National Association of Fleet Administrators, Inc
http://www.nafa.org/public/altfuelsidx.html
This site provides information on the laws and regulations addressing alternative fuel use.

DOE Alternative Fuel Vehicle Fleet Buyer's Guide
http://www.fleets.doe.gov/
This site has a searchable database of currently manufactured alternative fuel vehicles.

Engine and Vehicle Manufacturers

Gillig
http:/www.gillig.com
- alternate fuel buses

Neoplan USA
http:/www.neoplan.de
- alternate fuel buses

Cummins Engine Co**.**
http://www.cummins.com/bus/altfuels.html
- natural gas and propane engines

Detroit Diesel Corp.
http://www.detroitdiesel.com
- diesel and natural gas engines

Deere Power Systems
http://www.deere.com
- natural gas engines

Mack Trucks
http://www.macktrucks.com/product/vision/index.html
- natural gas trucks and engines

Freightliner Corporation
http://www.freightliner.com/
- trucks

Blue Bird Corp.
http://www.blue-bird.com
- school and transit buses

E Bus
http://www.ebus.com
- electric, hybrid shuttle and rubber tire trolley buses

Lockheed Martin Control Systems
http://www.lmcontrolsystems.com/PowerDrive.htm
- HybriDrive™ system

New Flyer Industries
http://www.newflyer.com/alfu/alfudef.htm
- buses

North American Bus Industries
http://www.nabiusa.com
- buses

Nova BUS
http://www.novabus.com/prodindex-e.htm
- buses

Orion Bus Industries
http://www.transit-center.com/Orion
- buses

Advanced Vehicle Systems, Inc.
http://www.avsbus.com
- electric and hybrid buses

Fuel Advocacy Groups

Fleets & Fuels Newsletter
http://www.augustpacific.com
Fleets & Fuels Newsletter, covering alternative technology vehicles, is published by August Pacific.

Natural Gas (Compressed and Liquefied)

National Gas Vehicle Coalition
http://www.ngvc.org
This site contains general information and relevant legislation on natural gas vehicles.
Gas Research Institute
http://www.gri.org
This site contains publication and research being done in using natural gas as an alternative fuel.

Propane (LPG)

National Gas Association
http://www.propanegas.com/npga/
National Gas Association develops safety standards for the use of propane.

Alcohol Fuels

Methanol

American Methanol Institute
http://www.methanol.org/altfuel/index.html
This site provides updates and information on methanol being used as an alternative fuel.

Ethanol

American Coalition for Ethanol
http://www.ethanol.org
American Coalition for Ethanol provides a general description of ethanol and ethanol refueling sites in the United States.

Ethanol Information Center
http://www.greenfuels.org/ethindex.html
This site gives environmental information about using ethanol as an alternative fuel, such as emissions reduction.

Biodiesel

National Biodiesel Board
http://www.nbb.org
Information on biodiesel can be found at this site. Also, emission reduction information can be found.

Electric Drivetrain Vehicles

Defense Advanced Research Projects Agency (DARPA) electric vehicle projects
http://www.ev.hawaii.edu
This site is the general site for DARPA electric vehicle projects and connection to the seven consortia:
Electricore - not available at this time
NAVC – www.NAVC.org

SMUD - www.smud.org/evs/index.htm
SCAT- www.advtrans.org
MARCAV www.MARCAV.ctc.com
HEVDP- www.ev.hawaii.edu/HEVDP/HEVDP.html
Calstart – www.calstart.org
Electric Power Research Institute (EPRI)
http://www.epri.com
This site provides information for electric and hybrid vehicle projects.

Idaho National Engineering and Environmental Laboratory
http://spiderman.inel.gov/
This site shows results from INEL's hybrid and electric vehicle research. It also has links to recent publications concerning electric vehicles.

Electric Transit Vehicle Institute
http://etvi.org

Battery

Electric Vehicle Association of the Americas
http://www.evaa.org/vehicles/index.html
This site has responses to frequently asked questions about electric vehicles and a list of currently available electric vehicles.

EV World
http://www.evworld.com
Houses an online "library" of EV-related reports, articles, and news releases. Also sign up for a weekly EV newsletter.

Electric Vehicle News Magazine
http://evnews.net
A monthly publication "dedicated to the EV industry"; this site offers a calendar of conferences, information on AFV conferences, and an archive of past issues. Visitors can subscribe to the print edition.

Fuel Cell

Fuel Cells 2000
http://216.51.18.233/index_e.html
General information and technical updates about fuel cells are provided by Fuel Cells 2000.

Ballard Fuel Cells
http://www.ballard.com/products.asp
This site provides product information on fuel cells manufactured for transportation application.

Plug Power
http://www.plugpower.com
This site provides product information on fuel cells manufactured for transportation application.

Hybrid Electric

U.S. Department of Energy Hybrid Vehicle Propulsion Program
http://www.hev.doe.gov/
This site contains general information on hybrid electric vehicles and the U.S. Department of Energy Hybrid Vehicle Propulsion Program.